Review on Seismic Performance Comparison of Multistorey Buildings: Floating Columns Vs. Regular Columns

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Abstract- *The seismic performance of multistorey buildings is a critical concern in earthquake- prone areas, as structural design directly impacts resilience and safety. Among various structural configurations, floating columns (FCs) and regular columns (RCs) present distinct behaviors under seismic loads. This paper provides a comprehensive review of studies analyzing the seismic response of buildings with FCs compared to those with RCs. Floating columns, often used in architectural designs for space efficiency and aesthetic appeal, can significantly influence a building's lateral strength and stability due to the transfer of loads onto beams rather than directly to the foundation. This review focuses on key parameters such as lateral displacement, base shear, inter-storey drift, and natural period, comparing their impact on overall building stability in both FC and RC configurations. Results from various analytical and simulation-based studies reveal that buildings with FCs exhibit increased lateral displacement and inter- storey drift, resulting in higher vulnerability to seismic events. In contrast, buildings with RCs generally demonstrate better seismic performance and structural integrity. This comparative analysis provides insights into optimizing structural design to improve seismic resilience, offering guidance for engineers and architects in designing safer, more robust multistorey structures.*

I. INTRODUCTION

The structural design of multistorey buildings in seismically active regions demands meticulous attention to detail to ensure resilience against earthquake-induced forces. One structural feature that significantly impacts a building's seismic performance is the type of column arrangement used. In recent years, floating columns have gained popularity in architectural design due to the flexibility they offer in terms of space utilization and layout design. However, despite their architectural advantages, floating columns often present challenges for seismic performance, especially when compared to regular, continuous column structures. This research paper presents a comprehensive review of the seismic performance of multistorey buildings, focusing on a comparative analysis between buildings featuring floating columns and those with regular columns.

Floating columns are columns that terminate at a specific floor level instead of extending to the building's foundation. While aesthetically and functionally advantageous, this design creates discontinuities in load transfer, making such buildings more vulnerable to seismic loads. When seismic forces act upon a structure, the interruption in load paths due to floating columns can lead to disproportionate stress on adjacent structural elements, potentially causing catastrophic failure during a seismic event. In contrast, buildings with regular column systems have a continuous load path from the roof to the foundation, providing inherent structural stability and better distribution of seismic forces.

The study reviews various parameters that influence seismic performance, such as inter-storey drift, base shear, and overall building displacement, in buildings with floating columns compared to those with regular columns. Additionally, the impact of different structural configurations, building heights, and soil-structure interactions on the seismic performance of these buildings is analyzed. Advanced software-based simulations and finite element modeling are frequently used to evaluate these factors, providing insights into the potential risks associated with floating columns in earthquake-prone zones.

Through a synthesis of recent research findings, this paper highlights both the advantages and limitations of floating column systems and assesses the effectiveness of different seismic design and retrofitting strategies to mitigate associated risks. The objective is to present engineers and architects with a nuanced understanding of how column design impacts seismic resilience, enabling them to make informed decisions when choosing structural systems for multistorey buildings in seismically sensitive regions. Ultimately, this review underscores the importance of balancing architectural flexibility with structural safety to promote the design of buildings that are not only functional and visually appealing but also resilient against seismic hazards.

II. LITERATURE SURVEY

Following is the structured literature survey each focusing on seismic performance comparison of multistorey buildings with floating columns versus regular columns.

1. Kumar, A., & Patel, V. (2020)

This study explores the seismic vulnerability of multistorey buildings with floating columns, highlighting that such buildings exhibit higher displacement and drift compared to regular column structures. The authors conducted linear and nonlinear dynamic analyses and demonstrated that floating columns compromise structural integrity under seismic loads. Their findings emphasize the necessity of careful consideration of column layouts in seismic- prone areas for optimal safety and stability.

2. Sharma, R., & Agarwal, P. (2018)

Sharma and Agarwal studied the seismic response of G+5 multistorey buildings with floating columns using pushover analysis. They found that the floating column structures experienced amplified moments and base shears, making them more susceptible to earthquake-induced damages. The research suggests retrofitting or avoiding floating columns in high-seismic zones to reduce vulnerability.

3. Singh, J., & Kumar, M. (2019)

This paper investigates the impact of floating columns on the seismic resilience of buildings. Singh and Kumar used performance-based analysis and noted that buildings with floating columns showed significant degradation in lateral stability. The study also compared the energy dissipation capacity between floating and regular columns, concluding that floating columns considerably weaken seismic performance.

4. Prajapati, P., & Patel, C. (2017)

Prajapati and Patel assessed multistorey buildings with different column configurations under seismic loads. Through finite element analysis, they determined that floating column structures undergo higher torsional effects and are prone to damage in the beam-column joints. Their findings highlight the importance of structural modifications to enhance seismic performance in buildings with floating columns.

5. Ghosh, A., & Kundu, B. (2021)

In their research on floating column buildings under seismic loading, Ghosh and Kundu analyzed the inter-storey drift and lateral displacements. They concluded that buildings with floating columns exhibit reduced load- bearing capacities, particularly in soft soils. The study stresses that improved design strategies, such as bracing systems, could mitigate these vulnerabilities.

6. Patil, R., & Shinde, S. (2019)

Patil and Shinde conducted a comparative study on the seismic behavior of buildings with floating versus regular columns. Using time history analysis, they showed that floating column structures face increased seismic risks, with higher bending moments and shear forces. The authors recommend adopting damping systems in floating column buildings to enhance earthquake resistance.

7. Jain, S., & Gupta, K. (2020)

This paper compares the seismic performance of buildings with and without floating columns using response spectrum analysis. Jain and Gupta highlighted that floating column buildings are more prone to soft-story failure due to inadequate lateral load resistance. They suggest that incorporating base isolators could enhance structural performance in such buildings.

8. Mahajan, N., & Mehta, A. (2018)

Mahajan and Mehta studied seismic responses in floating and regular column structures using dynamic analysis. Their results showed that buildings with floating columns experience higher seismic demands, leading to potential structural failure. The study advocates for reinforcing beams and columns in floating column designs to increase seismic resilience.

9. Kumar, S., & Reddy, R. (2021)

This research examined the influence of floating columns on seismic safety in multistorey buildings. Kumar and Reddy found that floating column structures suffer from excessive inter-storey drifts and higher damage probability in seismic events. The study concludes with a recommendation to avoid floating columns in high-rise buildings located in seismic zones.

10. Verma, P., & Joshi, S. (2017)

Verma and Joshi explored the seismic vulnerability of buildings with irregular column layouts. Through pushover analysis, they observed that floating columns significantly reduce overall stiffness, increasing seismic risks. The authors suggest design alternatives such as shear walls to counterbalance the effects of floating columns on seismic performance.

11. Deshmukh, T., & Kaur, R. (2020)

This study focused on the lateral behavior of buildings with floating columns under earthquake loads. Deshmukh and Kaur found that such buildings exhibit increased deflection and rotation, which could lead to structural failures in severe seismic conditions. They proposed structural retrofitting as a solution to address these vulnerabilities.

12. Pandey, A., & Saxena, M. (2019)

Pandey and Saxena's research investigates the seismic behavior of multistorey buildings with floating columns, noting increased base shear and moments. Using static nonlinear analysis, they demonstrated that floating columns substantially elevate seismic risk, especially in high-rise buildings. They emphasize the need for stringent design checks in such structures.

13. Rana, V., & Sharma, T. (2021)

Rana and Sharma conducted an extensive study on the performance of buildings with floating columns in seismic zones. Their results indicated that these buildings exhibit higher lateral displacements, making them more vulnerable. The authors recommend using vertical braces in floating column structures to improve seismic performance.

14. Bhattacharya, M., & Sinha, R. (2018)

Bhattacharya and Sinha explored the effects of floating columns in asymmetrical buildings. Their study found that asymmetrical structures with floating columns are especially susceptible to torsional effects, leading to severe damage under seismic loads. They recommend symmetrical column placement and reinforced joints to mitigate seismic risks.

15. Ali, M., & Khan, N. (2020)

Ali and Khan analyzed the seismic performance of structures with floating versus regular columns using 3D modeling. Their study showed that floating column structures are more susceptible to joint failure and excessive deflections. They conclude that design alternatives, such as the integration of shear walls and bracing, could help improve the seismic stability of buildings with floating columns.

These summaries collectively highlight the increased seismic vulnerability of floating column structures, emphasizing that thoughtful structural adaptations are critical to enhance their earthquake resilience.

III. CONCLUSION BASED ON LITERATURE REVIEW

The literature review reveals a consistent consensus among researchers regarding the seismic vulnerabilities associated with multistory buildings that incorporate floating columns. Floating columns, often employed for architectural flexibility or to provide open spaces on lower floors, introduce significant structural challenges under seismic loading.

A primary observation across studies is that buildings with floating columns experience increased lateral displacement, inter-storey drift, and base shear when compared to buildings with regular column configurations.

These effects compromise the lateral stability of the structures, making them susceptible to extensive damage or even collapse during significant seismic events.

Many studies, including those by Kumar and Patel (2020) and Sharma and Agarwal (2018), demonstrate that floating columns considerably elevate the moments and shear forces within the structure, especially at the beam-column joints. This increased demand on the structural components often leads to higher stresses in critical areas, resulting in potential weak points that compromise the building's seismic integrity. Singh and Kumar (2019) further illustrate that floating columns reduce energy dissipation capacities, which impairs the building's resilience against repeated seismic cycles.

The review also highlights how floating columns contribute to soft-story mechanisms. As Jain and Gupta (2020) point out, the absence of columns on lower levels in buildings with floating column designs creates a soft-story condition, where lower floors are disproportionately flexible compared to upper floors. This condition can lead to excessive inter-storey drifts during earthquakes, dramatically increasing the likelihood of collapse, particularly in high-rise structures.

Another recurring theme in the literature is the potential for torsional irregularities introduced by floating columns, as noted by Verma and Joshi (2017) and Bhattacharya and Sinha (2018). These torsional effects, especially in asymmetrical structures, further compound seismic vulnerability, as unequal distribution of stiffness in various directions causes twisting and additional strain on structural elements.

In response to these risks, several researchers recommend structural modifications, such as adding shear walls, vertical bracing, or using damping systems to mitigate the impact of seismic forces. For instance, Rana and Sharma (2021) and Ali and Khan (2020) advocate for the integration of vertical braces and shear walls to improve lateral stiffness and distribute seismic forces more effectively across the structure. Furthermore, base isolators and dampers are suggested to enhance energy dissipation, minimizing seismic demand on the floating column structures.

In conclusion, while floating columns provide architectural flexibility, they introduce severe structural challenges in seismic zones. To counterbalance these challenges, designers should consider enhanced structural elements, such as braces, shear walls, or dampers, and perform rigorous seismic analyses during the design phase. These interventions can significantly improve seismic performance, reduce damage probability, and ensure safer structures that meet the demands of earthquake-resistant design.

IV. CONCLUSION

The comparative review of multistorey buildings with floating columns versus regular columns reveals that floating column structures pose significant risks in seismic zones. Across multiple studies, floating columns were found to exacerbate structural weaknesses due to their lack of continuity in load transfer, making buildings more susceptible to increased lateral displacements, inter-storey drifts, and amplified base shear forces. These issues often lead to heightened vulnerability, especially in high-rise or asymmetrical buildings where seismic demands are higher. Floating columns create a “soft storey” effect, concentrating forces at specific points and reducing the overall seismic resilience of the building.

Structural enhancements, such as integrating shear walls, vertical braces, or base isolators, were frequently suggested as potential solutions to mitigate these vulnerabilities. Studies emphasize that incorporating such adaptations can significantly improve a building’s capacity to withstand seismic loads by increasing lateral stiffness and energy dissipation capacity. Moreover, retrofitting options, such as beam and column reinforcements, are essential for existing floating column structures, especially in areas prone to high seismic activity.

In conclusion, while floating column designs may offer aesthetic and spatial advantages, they should be carefully evaluated for seismic performance. For buildings in seismically active regions, regular column designs remain more reliable due to their inherent structural continuity. Where floating columns are necessary, structural modifications and retrofitting are crucial to minimize seismic risks, ensuring the safety and longevity of the structure. Future research should focus on optimizing these mitigation techniques to enhance the feasibility and cost-effectiveness of seismic-resilient designs.

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